OUTLINE SHEET 3-4-1
Heat Exchangers

A. Introduction

Heat exchangers are used throughout the engineering plant raise or lower the temperature of various fluids. This lesson will familiarize you with the parts and functions of various heat exchangers.

B. Enabling Objectives

3.11 **DESCRIBE** the basic types of heat exchangers.

3.12 **DESCRIBE** the purpose and operating principle of heat exchangers.

C. Topic Outline

1. Introduction
2. Overview
3. Operating Principles of Heat Exchangers
4. Classification of Heat Exchangers
5. Summary and Review
6. Assignment

ASSIGNMENT SHEET 3-4-2
Heat Exchangers

A. Introduction

This material is to be completed prior to the material being covered in class.

B. Enabling Objectives

Refer to enabling objectives in Outline Sheet 3-4-1.

C. Study Assignment

1. Read Information Sheet 3-4-3

D. Study Questions

1. What are the purposes of heat exchangers?
2. What is the advantage of using a double tube heat exchanger?
3. How does fins and dimples affect the rate of heat exchange?

INFORMATION SHEET 3-4-3
Heat Exchangers

A. Introduction

This information describes heat exchangers.

B. Reference

Fireman NAVEDTRA 12001
Machinist's Mate 3&2 NAVEDTRA 12144

C. Information

I. A heat exchanger is any device or apparatus that allows the transfer of heat from one fluid (liquid or gas) to another fluid.
   A. For heat to transfer from one fluid to another, there must be a difference in temperature between the two fluids.
   B. When two substances are placed in contact with each other, or near each other, heat will flow from the warmer object to the cooler one until both objects are of the same temperature.
   C. Heat transfer occurs at a faster rate when there is a large temperature difference between the two objects. There are three methods of heat transfer:
      1. Conduction - heat flows from the hotter to the colder region through physical contact between the two substances.
      2. Convection - heat flows from the hotter to the colder region through the circulation of a fluid such as air. There are two kinds of convection:
         a) Natural convection - the natural movement of the fluid as the warmer region rises and the colder region falls to replace the rising warmer region.
         b) Forced convection occurs when some mechanical device, such as a pump or fan, produces movement of a fluid.
      3. Radiation - the transfer of heat in the form of waves, similar to light or radio waves, without physical contact between the emitting and receiving substances.

II. Heat exchangers can be used for several purposes:
   A. Heaters - heat exchangers that raise the temperature of another fluid.
   B. Coolers - heat exchangers that lower the temperature of another fluid.

C. Condensers - heat exchangers that change the state of a fluid from a gas to a liquid. They can be classified in two categories.
   1. Main condensers - heat exchangers where exhaust steam from steam propulsion turbines is condensed as it comes in contact with the tubes through which cool sea water is flowing. The condensed steam is then returned to the system for reuse.
   2. Auxiliary condensers - heat exchangers where exhaust steam from turbogenerators (or any non-main propulsion source) is condensed.

III. Heat exchangers can be classified in many different ways:
   A. By the path of heat flow.
      1. Indirect-contact or surface heat exchangers - the heat flows from one fluid to the other fluid through another surface. There is no direct contact between the two fluids.
      2. Direct-contact heat exchangers - heat is transfered from one fluid to another by mixing the two fluids together.
   B. By the direction of fluid flow.
      1. Parallel flow type - both fluids flow in the same direction.
         a) Initially, at the inlet there is a large temperature difference resulting in a high rate of heat transfer.
         b) As flow continues, the two fluids will equal out in temperature.
      2. Counter flow type - the two fluids flow in opposite directions. They are used in applications that require large temperature changes in the cooled or heated fluids.
      3. Cross flow type - one fluid flows at right angles (90 degrees) with the other fluid. This type is most commonly used in condensers.
   C. By the internal surface.
      1. A heat exchanger is considered plain surface if the internal surface is relatively smooth.
      2. It is considered extended surface if the surface is fitted with rings, fins, studs, or some other kind of extension. The advantage here is the increase in heat transfer area without any substantial increase in overall size or weight.
   D. Indirect heat exchangers may also be classified by their construction. Basically, all surface heat exchangers are of a shell-and-tube construction. Some shell-and-tube types include:
      1. Straight tube - the tubes are usually arranged in a bundle and enclosed in a cylindrical shell.
         a) The tubes may be welded to or expanded into a tube sheet at each end.

2. U-Bend tube - also known as the return bend heat exchanger, consists of a bundle of U-shaped tubes inside a shell.
    a) Since the tubes are U-shaped, there is only one tube sheet.
    b) The shape also allows for thermal expansion and contraction.
3. Helical or Spiral tube - have one or more coils of tubing installed inside a shell.
    a) The tubes may be joined with headers at each end of the shell or case.
4. Double tube - have one tube inside another.
    a) One fluid flows through the inner tube, and the other fluid flows between the outer and inner tubes.
    b) The shells or outer tubes are usually arranged in banks.
    c) The tubes are connected at one end by a common tube sheet with a partitioned cover that serves to direct the flow.
    d) Doubled-tube heat exchangers are usually of U-bend construction to allow for expansion and contraction.
5. Double-tube heat exchangers are commonly used as air coolers for generators to prevent extensive damage in the event of tube leakage.
    a) The smooth-surfaced inner tube carries the cooling fluid.
    b) The outer tube has internal ribs that make contact with the outer surface of the inner tube.
    c) The failure of an inner tube can be detected by the cooling fluid leakage from the telltale drains.
6. Strut tube and plate tube are noticeably different in design from other surface heat exchangers.
    a) The tubes consist of pairs of flat, oblong strips.
    b) One fluid flows inside the tubes, and the other fluid flows around the outside.

E. Indirect heat exchangers can also be classified by the number of passes one fluid makes past the other.
1. In a single-pass unit, one fluid passes the other fluid only once.
2. In a multi-pass unit one fluid passes the other fluid more than once. Multi-pass flow may be obtained either by the arrangement of the tubes and the fluid inlets and outlets, or by the use of baffles.